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(71) Applicant *(for all designated States except US)*: N.V. BEKAERT S.A. [BE/BE]; Bekaertstraat 2, B–8550 Zwevegem (BE).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: HEIRBAUT, Guido [BE/BE]; Hoogkamerstraat 288, B–9140 Temse (BE). VAN DER GUCHT, Ann [BE/BE]; Bassijnstraat 11, B–9050 Gentbrugge (BE). VAN STEENLANDT, Wim [BE/BE]; Nachtegalenlaan 10, B–9100 St. Niklaas (BE).

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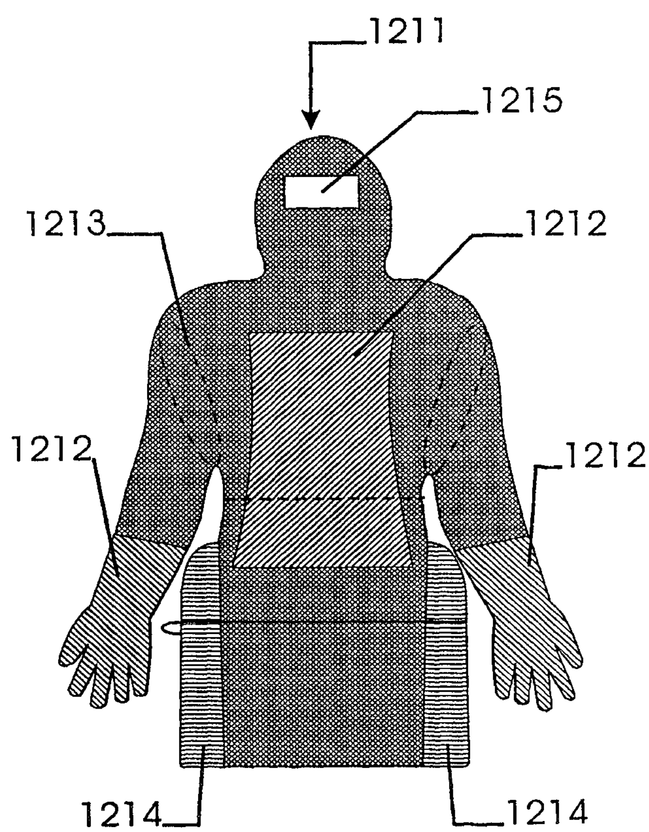
(54) Title: HEAT–RESISTANT GARMENT

(57) Abstract

A heat–resistant garment (111) has an outer surface (112) mainly comprises metal fibres to provide heat–resistance against contact heat. Different types of heat–resistant textile fabrics with metal fibres to provide the outer surface of the heat–resistant garment can be obtained by weaving, knitting or needle–punching. Heat–resistant garments can be used to provide protection against contact heat to person, animal or object on which the heat–resistant garment is worn.



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# HEAT-RESISTANT GARMENT

## Field of the invention.

The present invention relates to a heat-resistant garment providing protection against contact heat.

## Background of the invention.

Heat-resistant garments have been described in the literature into large detail. Many heat-resistant garments have been proposed to parts of human or animal bodies, such as hands, arms, legs, feet or trunk against radiation heat or contact heat.

In general, different heat-resistant textile fabrics and materials are used to provide heat-resistant properties of such heat-resistant garment. Amongst others, meta-aramid fibres, para-aramid fibres, glass fibres, ceramic fibres, carbon fibres, preox-fibers, leather, and Al-coatings are well known.

Depending on the type of heat (e.g. radiation heat or contact heat), the temperature against which protection is sought, and the time of protection desired, different combinations and materials are chosen.

Metal wires have also been described for protective garments, such as heat-resistant garments. Reflective textile products are known to protect human or animal bodies against radiation heat. The use of aluminised strands is known from AU513103. Also the use of metal filaments as a reflecting stand was mentioned in this document.

In DD248956 and DE3737299, one can learn that the use of metal wires in heat-resistant garment helps to improve the cut resistance, but the thermal insulation properties, which is an important property as far as protection against heat is concerned, is reduced, due to a high degree of thermal conductivity of the metal wires.

The main disadvantages as found in current state of the art, are twofold.

When heat-resistant garments, mainly out of meta-aramid or para-aramid fibres are used, these products are resistant to contact heat up to 500°C, but often only till 350 °C and show a good flexibility and drapeability. However, when contact temperatures between heat-resistant garment and hot objects higher than 500°C are applied, the heat-resistant garment quickly looses its heat-resistant properties, since the material in contact with the hot object starts funding or degenerating. The heat-resistant garment looses its thermal insulating character and its mechanical properties.

When a heat-resistant garment comprising glass or ceramic fibres is used, higher temperatures can be resisted. Disadvantages however are the thickness of these heat-resistant garments, and the inflexibility and non-drapeability. Further, glass and ceramic fibres are not very resistant to mechanical actions applied to the fibres in radial direction, which makes the heat-resistant garment sensitive for mechanical actions. Lifetime of these heat-resistant garments decreases because of mechanical wear.
Sometimes an extra aluminium-layer or aluminised strands are used. This layer gives the heat-resistant garment a better resistance to radiation heat due to its reflective properties, but it doesn't improve the resistance against contact heat. It usually makes the heat-resistant garment even less flexible and less drapeable.

## **Summary of the invention.**

The present invention relates to a heat-resistant garment having an outer surface mainly comprising metal fibres to provide a resistance against contact heat.

There is a major difference between resistance and protection to radiation heat and contact heat. In case a garment is to resist radiation heat, e.g. used as heat-resistant garment to protect the used against heating due to this radiation, the garment has to reflect as much as possible the energy, provided by the radiation of a heat source (e.g. fire, radiant burners, glowing objects). This reflection hinders the garment to be heated. The garment is to be provided by reflective material and is preferably as dense as possible.

In case a garment is to resist contact heat, the garment itself is heated due to energy provided via heat conduction. The garment is to absorb the energy, or in any case, prevent the energy to pass though the garment towards the object, which is protected by it.

According to the present invention a heat-resistant garment comprising one or more textile layers of which the outer textile layer is a heat-resistant textile fabric comprising metal fibres at the outer surface is provided. The outer surface of the garment is to contact the hot objects. Depending on the application, a metal fibre content of this outer surface of 50% to 100% by weight should be used. Preferably, more than 70% by weight, and most preferably more than 80% by weight should be metal fibres. An outer surface comprising only metal fibres gives also good results. The non-metallic fibres, used to provide the outer surface next to the metal fibres, are to be heat-resistant textile fibres e.g. para-aramid fibres, meta-aramid fibres, glass fibres, ceramic fibres, carbon fibres, preox-fibers, poly(p-phenylene-2,6-bezobisoxazole), hereafter also called PBO, or polybenzimidazole fibres.

Such a heat-resistant garment is resistant to high contact temperatures, depending on the ratio of metal fibres to non-metallic fibres, the type of non-metallic fibres, if any, and the type of metal alloy, used to provide the

outer surface. The presence of metal fibres increases the resistance against mechanical actions under higher temperature and it was found that the presence of metal fibres at the outer surface of the heat-resistant garment does not diminish, or even improves the insulating properties of the heat-resistant garment. This is surprising having regard to the high thermal conductivity of metals. An explanation is as follows.

It is clear that thermal energy, provided by contact heat to the outer surface of a heat-resistant garment, will be distributed through the whole of the garment in any direction, or will be used to heat the heat-resistant material.

In the prior art, fibres with a low coefficient of heat conduction are preferably used. This to prevent the thermal energy to be conducted towards the protected object. Since this low coefficient of thermal conductivity, the thermal energy was kept in the direct neighbourhood of the hot object contacting the heat-resistant garment, where it is used to heat the heat-resistant fibres. When the temperature of the hot object is too elevated, the fibres are degenerated, since too little energy is evacuated.

One may expect that, when fibres with a high coefficient of thermal conductivity are used, a significant heat protection may not be obtained since the thermal energy will be conducted easily towards the object to be protected. According to the invention however, surprisingly it was found that metal fibres provide significant thermal protection or thermal insulation, in spite of the good coefficient of thermal conductivity. Such thermal insulation is obtained when metal fibres are used to provide a heat-resistant fabric, which provides the outer surface of the heat-resistant garment and of which the filling rate is maximum 25%.

This filling rate is to be understood as the volume of the fibres, used to provide a certain fabric volume, compared to the volume of this fabric itself. More precise, suppose a fabric with a surface area LW ($cm^2$), a thickness D (cm) and a mass $M_f$ (g) is provided. The fabrics volume is than LW*D ($cm^3$). This fabric is provided by using fibres with specific weight $S_f$ ($g/cm^3$).
The volume of the fibres, used to provide this fabric, is $V_f$, being $M_f/S_f$ ($cm^3$). The filling rate of the fabric is to be understood as $100^*V_f/LW^*D$ (%).
In case the fabric comprise more than one fibre material, the volume of all fibres present is to be taken into account. E.g. 2 different fibre types with 2 different specific weights $S_{f1}$ and $S_{f2}$ are used. Each fibre type provides a part of the mass $M_f$ (g) of the fabric, called $M_{f1}$ (g) of the first type and $M_{f2}$ (g) for the second type and thus $M_f=M_{f1}+M_{f2}$. The filling rate is now calculated $100^*(V_{f1}+V_{f2})/LW^*D$, where $V_{f1}=M_{f1}/S_{f1}$ and $V_{f2}=M_{f2}/S_{f2}$.

The low filling rates of the heat-resistant fabrics as subject of the invention cause small contact points between the metal fibres, present either as a yarn or as such, and a large number of small open spaces between these fibres.

Thermal energy, which is applied to the surface of the heat-resistant garment as subject of the invention, will be hindered to flow through the garment towards the protected body or object. This because these small open spaces and small contact points disturb the thermal conductivity in this direction, in spite of the good thermal conductivity of the metal fibres.

The thermal energy will preferably be conducted to areas of the heat-resistant garment surrounding the contact points, since the fibres, mostly lying parallel to the surface of the heat-resistant garment, will conduct the thermal energy thanks to the good thermal conductivity.

Best insulating properties are found for heat-resistant garment as subject of the invention when the filling rate is below 25%, preferably less than 20% or even less than 15% or 10%.

One understands that the filling rate may not be too small, since no material is present to conduct the thermal energy. 2% may be seen as a lower limit.

Another advantage is that the lifetime of the heat-resistant garment according to the invention is increased, since the metal fibres do not degenerate at higher temperatures, e.g. at 600°C to 750°C for AISI 300-type stainless steel fibres, or 1000°C for Aluchrome-type fibres.

Heat-resistant garments as subject of the invention comprising meta-aramid or para-aramid fibres, are resistant to higher contact temperatures applied on the outer surface, compared to similar heat-resistant garment without metal fibres. The lifetime of heat-resistant garments as subject of the invention comprising meta-aramid or para-aramid fibres, is longer than the lifetime of a similar product without metal fibres on the outer surface under same temperature circumstances. When metal fibres and other heat-resistant fibre materials are blended, the metal fibres prevent the other fibres from degenerating to certain extend. Further, the metal fibres help the blend to resist to a larger extent mechanical actions under higher temperatures. These improvements are obtained without loosing flexibility or drapeability of the heat-resistant garment compared to a heat-resistant garment without metal fibres on the outer surface.

A heat-resistant garment mainly out of glass or ceramic fibres, but with an outer surface comprising metal, resists better the mechanical actions, caused by the contact of hot objects and outer surface of the heat-resistant garment so improving lifetime of such heat-resistant garment..

Also the flexibility and drapeability can be improved by adding metal fibres to the contact side of the heat-resistant garment.

In the scope of the invention, metal fibres are to be understood as fibres having an equivalent diameter of less than 50μm. More preferably, an equivalent diameter of less than 25μm., and most preferably between 5μm. and 13μm., such as 6μm., 8μm. or 12μm. is used for the outer surface of the heat-resistant garment. With equivalent diameter is meant the diameter of a circle, which has the same surface as the surface of the metal fibres being cut radial to their axis.

All types of metal fibres may be used. Usually, but not necessarily, stainless steel fibres are used. Alloys such as AISI 316 or AISI 316L, AISI 347, or other alloys out of the AISI 300 type are used. Also alloys out of the AISI-400 type, Aluchrome-type alloys or alloys as described in US-4597734 can be used. These fibres may be bundle drawn, as described in patent US-A-3379000, or may be made by shaving them from a coil, as described in patent US-A-4930199 or can be melt extracted. Also metal fibres produced as described in JP62260018 may be used.

These stainless steel fibres, or yarns provided by using these, are flexible, are dull and have an essentially grey colour. Fabrics made using these stainless steel fibres or yarns are also dull and don't offer significantly more protection against radiation heat.

To provide to the heat-resistant garment sufficient thermal insulating properties next to resistance against contact heat, additional layers of heat-resistant textile fabrics may be used, one on top of the other, additionally to the heat-resistant textile fabric providing the outer surface of the heat-resistant garment. The other heat-resistant textile fabrics, which form the heat-resistant garment together with the heat-resistant

textile fabric comprising metal fibres, may be made out of other heat-resistant textile fibres such as para-aramid fibres, meta-aramid fibres, glass fibres, ceramic fibres, carbon fibres, preox-fibers, para-aramid fibres, meta-aramid fibres, glass fibres, ceramic fibres, carbon fibres, preox-fibers, poly(p-phenylene-2,6-bezobisoxazole) or polybenzimidazole fibres, or a combination thereof, and may comprise metal fibres as well.

Next to the different layers of heat-resistant textile fabrics, layers of textile fabric providing other properties, e.g. comfort during wear, cut resistance and resistance against moisture may be added, underneath the layer of heat-resistant textile fabric providing the outer surface of the heat-resistant garment.

To form a heat-resistant garment comprising different layers of textile fabric as subject of the invention, the different textile layers forming the heat-resistant garment don't have to be fixed together permanently, e.g. by means of confection. The different layers of the heat-resistant garment may be used separately one above another. This gives the additional advantage that in case one layer is worn out, only this layer is to be replaced.

The outer heat-resistant textile fabric may comprise metal fibres either distributed through the whole volume of the fabric, or only on the outer surface of this heat-resistant textile fabric, which is to provide the outer surface of the heat-resistant garment. For calculation of the filling ratio, only the depth of the fabric comprising metal fibres, and the fibre volumes providing this depth are to be taken into account.

The outer heat-resistant textile fabric comprising metal fibres at its outer surface, can be obtained by using different textile techniques. This fabric

can be, as a matter of non-limiting examples, a woven fabric, a knitted fabric, a braided fabric or a non-woven fabric.

In case the outer heat-resistant textile fabric is a woven fabric, different woven structures can be used. The woven fabric can either be mono- or multilayer. By multilayer is meant that different layers of weft yarns can be found, where these different layers of weft yarns are combined one to the other by the warp yarns.
The woven fabric can either be in total made out of yarns comprising metal fibres, or the yarns comprising metal fibres can be located at this side of the heat-resistant textile fabric, providing the outer surface of the heat-resistant garment.
Also terry cloth, where the whole or only the loops are made out of metal fibre comprising yarns, can be used, providing that the side which comprises the metal fibres is used as the outer side of the heat-resistant garment comprising metal fibres.
With terry cloth is meant a woven fabric, which has a yarn forming loops on one or both sides.

In case the outer heat-resistant textile fabric is a knitted fabric, the fabric can either be warp or weft knitted. Either single bed or double bed knitted fabrics for warp and weft knitted fabrics can be used.

When the outer heat-resistant textile fabric is a weft knitted fabric, the fabrics are obtainable on a flat or circular knitting machine with a gauge between 2 and 32. The term "gauge" is the number of needles per inch of the needle bed.

The knitted fabric can either be made in total out of yarns comprising metal fibres, or the yarns comprising metal fibres can be located at this side of the heat-resistant textile fabric, providing the outer surface of the heat-resistant garment.

For single bed structures, a fabric with only one side comprising yarns with metal fibres, and the other side comprising yarns without metal fibres can be obtained by using the plating technique. Plating technique means that two different yarns, e.g. one comprising metal fibres, the other not, are guided to the same needle, where both yarns are incorporated in the same stitch in such a way that one yarn always comes to the face side of the fabric and the other always comes on the reverse side of the fabric. By applying this technique, a single bed fabric can be obtained, with a face side comprising the yarns with metal fibres, and a reverse side comprising the yarn without metal fibres.
When double bed structures are used to provide the outer heat-resistant textile fabric, a heat-resistant textile fabric with one side comprising yarns with metal fibres and the other side comprising yarns without metal fibres can be obtained as follows. The yarn with metal fibres is knitted on one needle bed. The yarn without metal fibres is knitted on the other bed. Both sides so obtained are connected during knitting by e.g. tuck stitches on both beds during same course. This results in a fabric with one side with metal fibres and the other side without metal fibres.

In case the outer heat-resistant textile fabric is a non-woven fabric, the fabric can either be obtainable by needle-punching or stitch-bonding techniques.

The non-woven fabric can either be in total made out of one or more layers comprising metal fibres, or the metal fibres can be located at one outer side of the heat-resistant textile fabric, providing the outer surface of the heat-resistant garment.

The outer heat-resistant textile fabric can also be a braided product.

The metal fibres are present in the heat-resistant garment as staple fibres or by using yarns, of which the metal fibres are part. These yarns can comprise multifilament metal fibres or staple metal fibres.

In case a non-woven fabric is used, metal fibres are used as staple fibres, either used to form a 100% metal fibre non-woven, or blended with other non-metallic heat-resistant fibres.

In case woven, braided, knitted or other fabrics, yarns comprising metal fibres are used. The fibre materials, of which at least one are metal fibres, can be intimately blended and possibly plied to a two or more plied yarn or the yarn can be a two- or more plied yarn, where some or all of the single yarns are made out of one fibre type. By plying yarns, it is meant that two or more yarns are given torsion round the direction of the axis's of the yarns. The single yarns can either be spun yarns or multifilament yarns.

Different yarns with different counts can be used to provide the outer heat-resistant textile fabric as subject of the invention. The metrical number (Nm) of a yarn is an expression for the count or fineness of the yarn. It gives you the length of yarn that has a weight of 1 gram. To obtain a heat-resistant garment as subject of the invention, yarns comprising metal fibres with metrical number up to Nm 15 can be used. However, yarn properties as an example and not restrictive such as count, number of plies, twist and twist direction and spinning processes used to provide the yarns are not significant and can be chosen to provide the desired properties for the heat-resistant garment.

Properties of the heat resistant fabrics, other than the filling rate of the heat-resistant fabric, being the outer heat-resistant fabric comprising metal fibres of the heat-resistant garment, may be chosen to provide desired characteristics of the heat-resistant garment.

To be a heat-resistant garment as subject of the invention, it is sufficient that at least one zone of the outer surface of the heat-resistant garment is to comprise metal fibres has a filling rate of less than 25%. One understands that these zones are to contact the hot objects. When different heat-resistance properties are required on different zones of one heat-resistant garment as subject of the invention, different types of outer surfaces, which are in the scope of the invention, can be used.

These heat-resistant garments may cover parts or all the human or animal body to protect it from contacting hot objects, such as in a furnace heated metal objects, sparks caused by welding operations or sparks or drops of molten materials, which might come into contact with the human or animal body and so causing injuries. Heat-resistant gloves, mittens, aprons, socks, stockings, leggings, overalls, jackets, shirts, trousers, balaclavas, caps and smocks are such heat-resistant garments.

A heat-resistant garment as subject of the invention can also be used to provide heat-resistant garments, to be used above the conventional protective garments, worn underneath.

**Brief description of the drawings.**

The invention will now be described into more detail with reference to the accompanying drawings wherein

-FIGURE 1 is a view of a heat-resistant garment as subject of the invention.

-FIGURE 2 is a schematic view of a cross section of a heat-resistant garment as subject of the invention.

-FIGURE 3 is a knitting sequence, which describes a knitting structure useful to provide the heat-resistant textile layer to be used as outer

textile layer for an embodiment of a heat-resistant garment as subject of the invention.

-FIGURE 4 is a front view of a knitted fabric, obtainable by plating techniques.

-FIGURE 5 is a schematic view of a double bed knitted structure.

-FIGURE 6 is a schematic view of a cross section in warp direction of a multilayer woven fabric.

-FIGURE 7 is a schematic view of a cross section in warp direction of a terry cloth woven fabric.

-FIGURE 8 is a schematic view of a cross section of a non woven, needle-punched fabric

-FIGURE 9 is a heat resistant glove

-FIGURE 10 is a schematic view of a cross section of a heat resistant glove

-FIGURE 11 is a view of a mitten used to protect a protective glove worn inside this mitten

-FIGURE 12 is a view of a heat-resistant garment where only partially a heat-resistant garment as subject of the invention is used.

**Description of the preferred embodiments of the invention.**

An embodiment of the heat-resistant garment as subject of the invention, is shown in figure 1.

The heat-resistant garment 111 comprises an outer surface 112 and an inner surface 113. Outer surface 112 comprises metal fibres to provide contact heat-resistance to this outer surface.

In the scope of the invention, the heat-resistant garment 111 can be a garment, comprising one or more layers of textile fabric 114, 115, 116, 117 and 118. The outer layer 114 is to be a heat-resistant textile fabric of which the outer surface 112 comprise metal fibres.

Next to the outer layer 114, the other layers may have heat-resistant properties. Other properties, such as cut resistant, resistance against chemical agents and others can be added to the heat-resistant garment by using textile layers providing this property.

An embodiment of a heat-resistant garment as subject of the invention is a heat-resistant garment out of 3 layers, as shown in figure 2. The outer layer 121 is a knitted fabric comprising metal fibres. The heat-resistant garment further comprises two other layers 122 and 123.

Outer layer 121 may be provided by knitting metal comprising yarns according to the knitting structure as shown in FIGURE 3. The fabrics are provided by knitting on a double bed knitting machine, type "Knit and Wear" gauge 5.2 from H. STOLL GmbH & Co. – Reutlingen (D), knitted on all needles 134. Three yarns (131, 132 and 133) are knitted consecutive on the front (F) and rear (R) needle bed following the knitting steps I to IV as shown in FIGURE 3. Different heat-resistant fabrics as subject of the invention were provided using different metal containing yarns as can be seen in the table underneath (sample 2 to 6). As a reference, a similar fabric was provided out of PBO (sample 1, not in the scope of the invention). The time s, necessary to increase the temperature underneath the fabric with 10°C, when an object of 250°C was contacting the outer surface, was measured. This test was done according the European Standard EN702 "protective clothing – protection against heat and flame – test method : determination of the contact heat transmission through protective clothing or its materials". Results are shown in table I. KEVLAR® is a trademark of DUPONT, KERMEL® is a trademark of RHONE POULINC.

As can be noticed, the 100% metal samples offer very good results, compared to the textile fabric out of 100% PBO.

| sample | raw material | | content (%weight) | | specific mass | | fabric specific weight | fabric thickness | filling ratio | time s |
|---|---|---|---|---|---|---|---|---|---|---|
| | metal | polymer | % metal | % polymer | metal *($g/cm^3$)* | polymer *($g/cm^3$)* | *($g/dm^2$)* | (mm) | *(%)* | *(sec)* |
| 1 | AISI 316L | Kevlar® | 70,00 | 30,00 | 8,00 | 1,44 | 13,20 | 2,38 | 16,41 | 12,00 |
| 2 | AISI 316L | PBO | 70,00 | 30,00 | 8,00 | 1,56 | 13,25 | 2,44 | 15,19 | 9,00 |
| 3 | - | PBO spun | 0,00 | 100,00 | 8,00 | 1,56 | 5,79 | 2,10 | 17,69 | 7,00 |
| 4 | Fecralloy | Poly amide | 99,13 | 0,87 | 8,00 | 1,38 | 14,97 | 2,49 | 7,83 | 15,00 |
| 5 | AISI 316L | Kermel® | 70,00 | 30,00 | 8,00 | 1,34 | 13,66 | 2,71 | 15,69 | 13,00 |
| 6 | AISI 316L | - | 100,00 | 0,00 | 8,00 | 0,00 | 26,82 | 2,68 | 12,51 | 14,00 |

TABLE I

An alternative embodiment is provided using an outer layer 121 out of 100% stainless steel yarns, alloy AISI 316L. It is a single jersey 1/3 knitting structure, obtained by making this structure with a stainless steel spun yarn, e.g. a 2-plied yarn with a metrical number of 5.5

A knitting structure "single jersey 1/3" is a single bed knitting structure where each row of stitches is made out of three yarns. All needles in the bed are grouped per three. The first yarn makes stitches on every first needle of each group of needles on the needle bed, where the second yarn is knitted in the same stitch row on every second needle of each group of needles. The third yarn is knitted on every third needle of each group of needles. This heat-resistant textile fabric has a thickness of 1.08mm, a surface weight of 957g/m² and so a filling ratio of 11.07%.

The heat-resistant garment comprises two other layers of heat-resistant textile fabric 122 and 123, being two layers of needle-punched para-aramid fibres. Layer 122 has a thickness of 2.53 mm, where layer 123 has a thickness of 1,67 mm.

An alternative for this embodiment is a heat-resistant garment with more or less layers of textile fabric. These additional layers can be heat-resistant or offer other properties, additional to the heat-resistance to the heat-resistant garment.

In an other alternative, other fibres for the layers 122 and 123, or even additional layers if present, can be used . Other suitable fibres, by way of example and not limitation, are meta-aramid fibres, glass fibres, ceramic fibres, carbon fibres, preox-fibers, cotton fibres, poly(p-phenylene-2,6-bezobisoxazole) or polybenzimidazole fibres, or a combination thereof.

Heat-resistant textile fabric 121 can also be provided by knitting a yarn, comprising fibres of two or more different heat-resistant materials, of

which at least one material is metal. A yarn comprising 70% weight metal fibres and 30% weight PBO-fibres, with a metrical number of 7 can be used. A single bed knitting structure "single jersey 1/3" can be used to provide with this yarn a heat-resistant textile fabric 121. The filling rate for this heat-resistant fabric is 18.86%. The fabric has a thickness of 1.06mm and a weight of 714.6 g/m².

In another embodiment of the heat-resistant garment as subject of the invention, the outer layer of the heat-resistant textile fabric comprising metal fibres is a circular or flat knitted, single bed, weft knitting, obtainable by using plating techniques. As shown in figure 4, the yarn 141, comprising metal fibres, will always be found on the left side 143 of the fabric, where the yarn 142, which may comprise metal fibres as well, is always found on the right side 144 of the fabric. Using the side 143 of this fabric as the outer surface 112 of the outer layer 114 of heat-resistant textile fabric 111 which provides the surface of the heat-resistant garment with metal fibres 112, another embodiment of the heat-resistant garment as of present invention is obtained.
An outer layer comprising metal fibres as an example of this embodiment is provided using a metal fibres spun yarn, e.g. a 2-plied yarn with a metrical number of 5.5 as yarn 141, while a glass fibre multifilament yarn of metrical number 7.4 is used for yarn 142. These two yarns are knitted together, using plating techniques, into a single bed knitted structure "single jersey 1/3".
An alternative is using a yarn comprising 70% weight metal fibres and 30% weight para-aramid fibres, with a metrical number of 7 as yarn 141.

Another embodiment of the heat-resistant garment as subject of the invention is obtained by making the outer surface 112 of the heat resistant textile fabric 114 out of a circular or flat knitted, double bed knitting, obtainable by using a knitting structure as schematically shown in figure 5. The yarn 151, comprising metal fibres, will only be knitted on

the front needle bed 155. A yarn 154, which may comprise metal fibres as well, is knitted only on the rear needle bed 156. Yarns 152 and 153, which may comprise metal fibres, are used to combine the stitches made on front and rear needle bed. Using this or similar knitting structure, one obtains a knitted fabric with a front side 157 comprising metal fibres, provided by yarn 151, and a rear side 158, which comprises metal fibres in case yarn 154 comprises metal fibres. Using the side 157 of this fabric as the outer surface 112 of the outer textile layer 114 of heat-resistant textile fabric 111, another embodiment of the heat-resistant garment as of present invention is obtained. As an example, a metal fibre spun yarn, e.g. a 2-plied yarn with a metrical number of 5.5, is used as yarn 151, where para-aramid yarns with metrical number 12.5 are used for the yarns 152, 153 and 154. The garment provided as such, using the side 157 of this fabric as the outer surface 112 of the outer textile layer 114 of heat-resistant textile fabric 111, is another embodiment of the heat-resistant garment as of present invention.

Other embodiments of the heat-resistant garment as part of the invention can be obtained by using a woven fabric comprising metal fibres for the outer layer 114. This woven fabric can be a single layer woven fabric, of which warp yarns and/or weft yarns comprise metal fibres, or it can be a multi-layer fabric as an example is shown in figure 6.

The fabric shows 3 layers 161, 162 and 163. For all layers, the same weft yarns 164 can be used. One set of warp yarns 165, comprising metal fibres, is used to provide the firs layer 161 and to connect this layer to the second layer 162. A second set of warp yarns 166 is used to provide the third layer 163 and connect it to the second layer 162. The fabric side 167 comprises metal fibres provided by the yarn 165. Using the side 167 of this fabric as the surface 112 of the outer layer of heat-resistant textile fabric 111 another embodiment of the heat-resistant garment as of present invention is obtained.

An outer layer comprising metal fibres as an example of this embodiment is provided using a weft yarn 164 and a warp yarn 166, having a metrical number of 0.7 and consisting of 80 % of weight metal fibres of type stainless steel fibres of type AISI 316L and having an equivalent diameter 12µm, and 20% para-aramid fibres. The warp yarn 165 is a 100% stainless steel fibre yarn AISI 316L and having an equivalent diameter 12µm. The yarn 165 has a metrical number of 0.3 .

Another woven fabric to provide the outer layer 114, can be a terry cloth as shown in FIGURE 7. A weft yarn 171, which may comprise metal fibres is used. 3 different warp yarns are used, being 172, 173 and 174. To provide a side 175 to the fabric which contains metal fibres, it is necessary that the warp yarns 172 contain metal fibres. These yarns 172 make loops at side 175. The other warp yarns 173 and 174 may contain metal fibres as well. Using the side 175 of this fabric as the outer surface 112 of the outer layer 114 of heat-resistant textile fabric 111 another embodiment of the heat-resistant garment as of present invention is obtained.
An outer layer comprising metal fibres as an example of this embodiment is provided using a weft yarn 171 and a warp yarn 173 and 174, having a metrical number of 7 and consisting of 70 % of weight metal fibres of type stainless steel fibres of type AISI, and 20% para-aramid fibres. The warp yarn 172 is a 100% stainless steel fibre yarn AISI 316L and has a metrical number of 5.5 .

Other embodiments of the heat-resistant garment as part of the invention can be obtained by using a non woven fabric comprising metal fibres for the outer layer 114. It can be a non woven fabric, a needle-punched fabric or a stitch bonded fabric. An example of a needle-punched fabric is shown in figure 8.

In this example one can recognise 3 different layers in the non woven, being 181, 182 and 183.
Layer 181 comprises metal fibres, providing an outer side 184 with metal fibres to the non woven fabric.
Layer 183 is also a part of the non woven , which may comprise metal fibres. Layer 182 is a woven textile fabric which is part of the non woven fabric, and which increases the dimensional stability of the non woven . These 3 layers are hold together by e.g. needle-punching or stitch bonding techniques.

An example of a needle-punched fabric is a 3 layer non woven fabric as shown in figure 8, where layer 181 is a layer of metal fibres of 12μm equivalent diameter, layer 182 is a woven fabric, made out of para-aramid multifilament yarn, and layer 183 is a layer comprising para-aramid fibres and preox-fibers.

Also in the scope of the invention, heat-resistant garments, to be more specific by way of example and not restrictive, gloves, mittens, aprons, socks, stockings, leggings, overalls, jackets, shirts, trousers, balaclavas, caps and smocks, are made out of a heat-resistant garment as subject of the invention.

Figure 9 shows a glove 191, of which the palm 192 and the back 193 are made out of two different heat-resistant garments 194 respectively 195 as subject of the invention.

As shown in figure 10, which is a cross-section of the heat-resistant glove 191 in the plane AA', heat-resistant garment 194 and 195 can be of a different construction.

An embodiment of a heat-resistant glove is explained as follows. The heat-resistant garment 194, providing an outer side 1006 with metal

fibres to the back 193 of the heat-resistant glove 191, is made out of two layers of textile fabrics 1001 and 1002. Layer 1001 comprises metal fibres at its outer surface 1006, which is at the same time the outer side of the back 193 of the heat-resistant glove 191. Layer 1001 is a knitted fabric as shown in figure 5, in which the yarn 151 comprising metal fibres is a 100% stainless steel fibre yarn, metrical number 5.5 comprising fibres of alloy AISI 316L, having an equivalent diameter of 12µm. Yarns 152 and 153 are the same yarns as used for yarn 151. Yarn 154 is a para-aramid yarn with metrical number 25. Layer 1001 is used in such a way that the outer surface 1006 it is provided by the yarn 151.

Layer 1002 is a knitted fabric as shown in figure 5, in which the yarns 151, 152 and 153 are para-aramid yarns with metrical number 25. Yarn 154 is a cotton yarn with metrical number 25. Layer 1002 is used in such a way that the inner surface 1008 is provided by the yarn 154.

Layer 1005 comprises metal fibres at its outer side 1007, which is at the same time the outer side of the palm 192 of the heat-resistant glove 191. Layer 1005 is a knitted fabric as shown in figure 5, in which the yarn 151 comprising metal fibres is a 100% stainless steel fibre yarn, metrical number 5.5 comprising fibres of alloy AISI 316L, having an equivalent diameter of 12µm. Yarns 152 and 153 are the same yarns as used for yarn 151. Yarn 154 is a para-aramid yarn with metrical number 25. Layer 1005 is used in such a way that the outer surface 1007 it is provided by the yarn 151.

Layer 1003 is a knitted fabric as shown in figure 5, in which the yarns 151, 152 and 153 are para-aramid yarns with metrical number 25. Yarn 154 is a cotton yarn with metrical number 25. Layer 1003 is used in such a way that the inner surface 1009 it is provided by the yarn 154.

Layer 1004 is a knitted fabric, made by applying the knitting structure as shown in figure 5, where all yarns 151, 152, 153, 154 used are para-aramid yarns with metrical number 25.

All layers are obtainable using a gauge 12 flat knitting machine.

Another embodiment of a heat-resistant glove is explained by use of figure 11. A mitten 1102, obtained by confection of a heat-resistant garment as subject of the invention, is used to protect a protective glove 1101, worn under the heat-resistant garment as subject of the invention. The mitten 1102 is made out of a knitted fabric with structure single jersey 1/3, obtained by knitting 100% stainless steel fibre yarn, metrical number 5.5 comprising fibres of alloy AISI 316L, having an equivalent diameter of 12μm, or made out of a blended yarn, comprising 70% weight stainless steel fibres, of alloy AISI 316L, having an equivalent diameter of 12μm and 30% weight para-aramid fibres.

According to the scope of the invention, it is not necessary that the total surface of the heat-resistant garment is made out of heat-resistant garment as subject of the invention. As shown in figure 12, the heat-resistant garment can also be used locally, providing these places of the garment different heat-resistant properties.

An example is given in figure 12, where a heat-resistant over-all 1211 comprises 2 different zones1212 and 1213, of which the outer layers are a heat resistant fabric as subject of the invention. Heat-resistant zone 1212 is made out of 4 layers of heat-resistant textile fabric. Heat-resistant zone 1213 is made out of 2 layers of heat-resistant textile fabric. All parameters of heat-resistant zones 1212 and 1213, such as thickness, weight, metal content, type of heat-resistant fibre material, filling rate, textile structures, are chosen to provide to heat-resistant zone 1212 superior heat-resistant properties than to heat-resistant zone 1213. Two parts of a para-aramid woven structure 1214 are used to close the heat-resistant over-all, and a heat-resistant window 1215 is provided to enable the user to look through the garment, providing sufficient protection to the eyes.

The choice of the properties of the heat-resistant textile fabrics used to provide certain zones of the garment depends upon the protection as wanted for these zones. Also other properties, such as flexibility, weight, thickness and other properties can influence the choice on the used products to provide certain parts of the garment.

As noticed by people skilled in the art, heat-resistant garments as subject of the invention can be obtained by normal confection techniques as known in the art.

## CLAIMS

1. A heat-resistant garment providing resistance against contact heat comprising an outer layer of heat-resistant textile fabric, said heat-resistant textile fabric has an outer surface, characterised in that said outer surfaces mainly comprises metal fibres.

2. A heat-resistant garment providing resistance against contact heat as in claim 1 wherein said outer surface consists of metal fibres.

3. A heat-resistant garment providing resistance against contact heat as in claim 1 or 2, wherein the filling rate of said outer layer of heat-resistant textile fabric is less than 25%.

4. A heat-resistant garment providing resistance against contact heat as in claim 1 to 3, wherein said product comprises more than one layer of textile fabrics.

5. A heat-resistant garment providing resistance against contact heat as in claim 1 to 4, wherein said metal fibres have an equivalent diameter of less than 50μm.

6. A heat-resistant garment providing resistance against contact heat as in claim 1 to 5, wherein said metal fibres are stainless steel fibres.

7. A heat-resistant garment providing resistance against contact heat as in claim 1 to 6 wherein said metal fibres are filaments, plied together to form a multifilament yarn.

8. A heat-resistant garment providing resistance against contact heat as in claim 1 to 6 wherein said metal fibres are staple fibres, plied

together to form a spun yarn.

9. A heat-resistant garment providing resistance against contact heat as in claim 1 to 8, characterised in that said outer surface is provided by a woven fabric.

10. A heat-resistant garment providing resistance against contact heat as in claim 1 to 8, characterised in that said outer surface is provided by a knitted fabric.

11. A heat-resistant garment providing resistance against contact heat as in claim 10, wherein said knitted fabric is obtainable by warp knitting.

12. A heat-resistant garment providing resistance against contact heat as in claim 10, wherein said knitted fabric is obtainable by weft knitting.

13. A heat-resistant garment providing resistance against contact heat as in claim 1 to 8, characterised in that said outer surface is provided by a braided fabric.

14. A heat-resistant garment providing resistance against contact heat as in claim 1 to 8, characterised in that said outer surface is provided by a non woven fabric.

15. A heat-resistant garment providing resistance against contact heat as in claim 14, wherein said non-woven fabric is obtainable by needle-punching.

16. A heat-resistant garment providing resistance against contact heat as in claim 14, wherein said non-woven fabric is obtainable by stitch

bonding.

17. A heat-resistant garment providing resistance against contact heat as in claim 10 to 12, wherein said metal fibres are provided to said outer surface of said heat-resistant garment by using plating techniques.

18. A heat-resistant garment providing resistance against contact heat as claim 10 to 12, wherein said metal fibres are provided to said outer surface of said heat-resistant garment using double bed knitted structure.

19. A heat-resistant garment providing resistance against contact heat according to claim 18, wherein only the side of said double bed structure to be used as said outer surface of said heat-resistant garment comprises said metal fibres.

20. A heat-resistant garment providing resistance against contact heat and comprising different zones, characterised in that at least one of said zones comprises metal fibers as claimed in claim 1 to 19.

21. A heat-resistant garment providing resistance against contact heat as in claim 3 to 20, wherein said layers of heat-resistant textile fabrics are not fixed permanently to each other.

22. A heat-resistant garment providing resistance against contact heat as in claim 1 to 20 wherein said garment is a glove.

23. Use of a heat-resistant garment providing resistance against contact heat as in claim 1 to 21 to protect human of animal body against injuries, caused by contact of said body with hot objects.

24. Use of a heat-resistant garment providing resistance against contact heat as in claim 1 to 21 to protect protective garments against wear, caused by contact of said protective garment with hot objects.

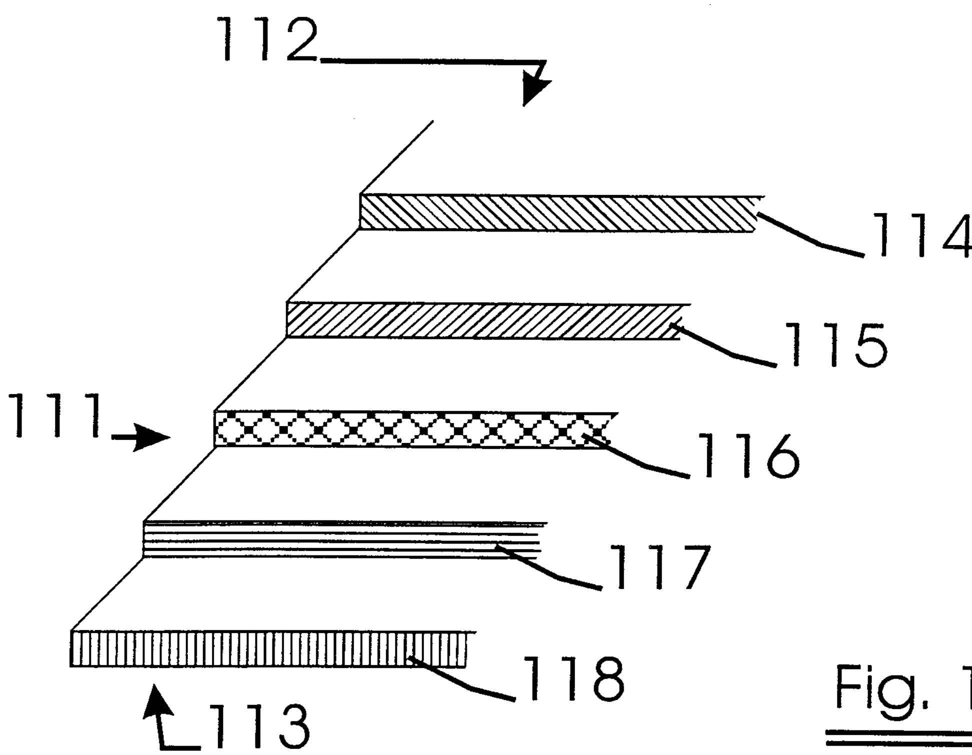


Fig. 1

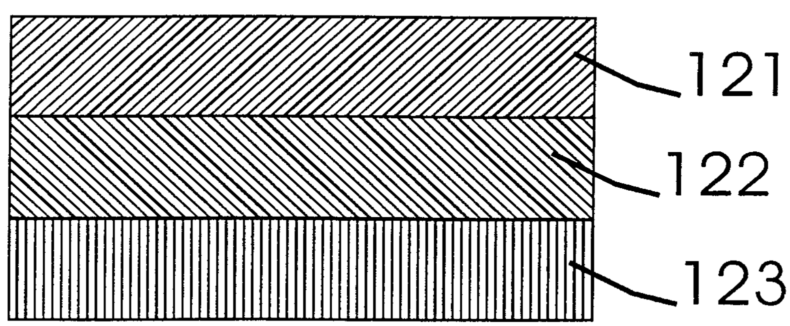


Fig. 2

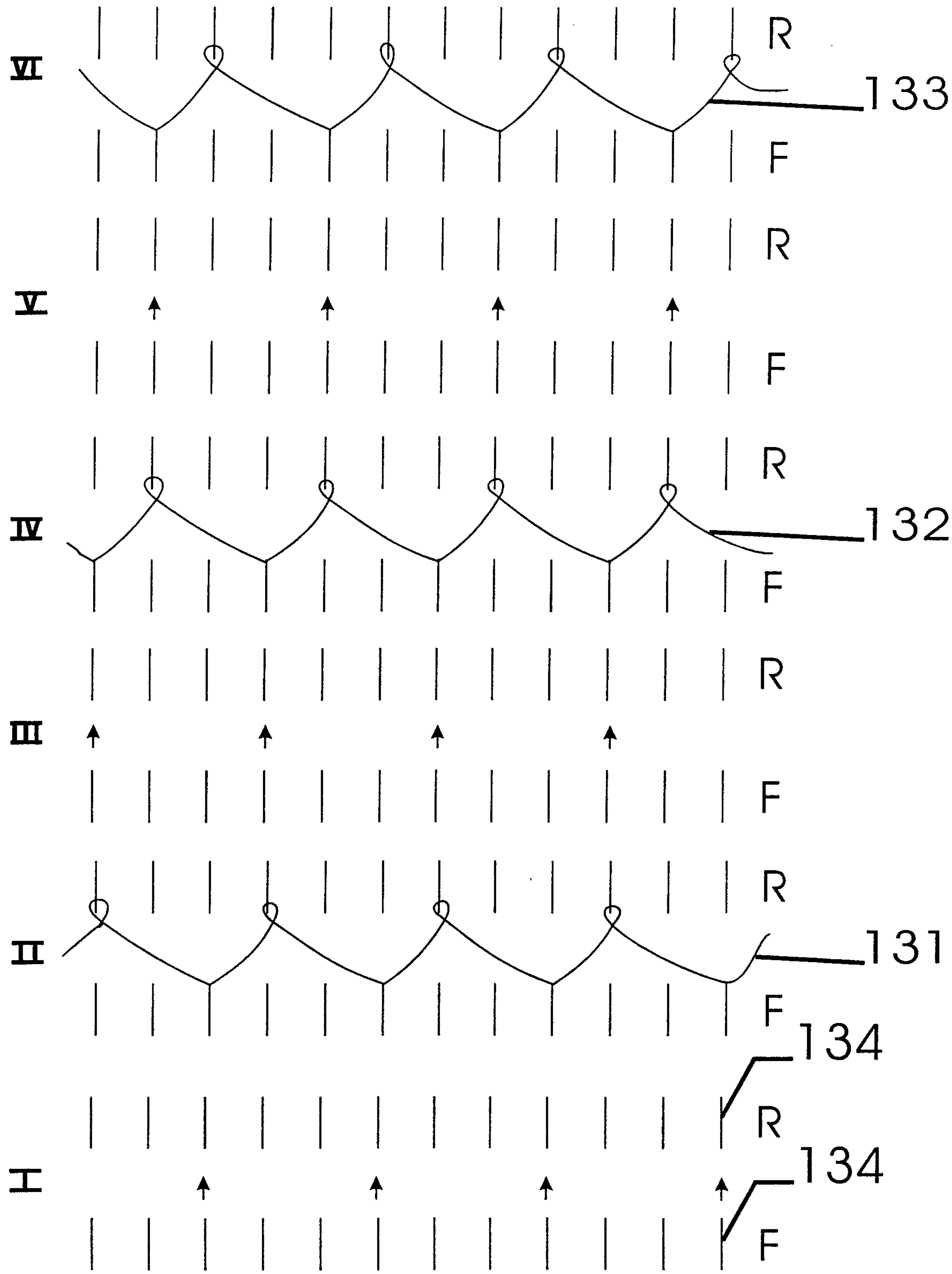


Fig. 3

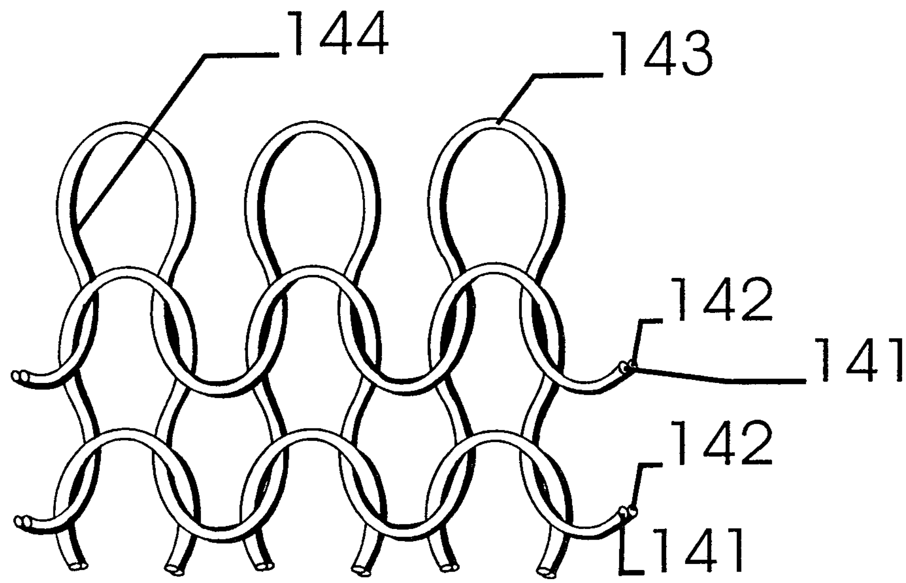


Fig. 4

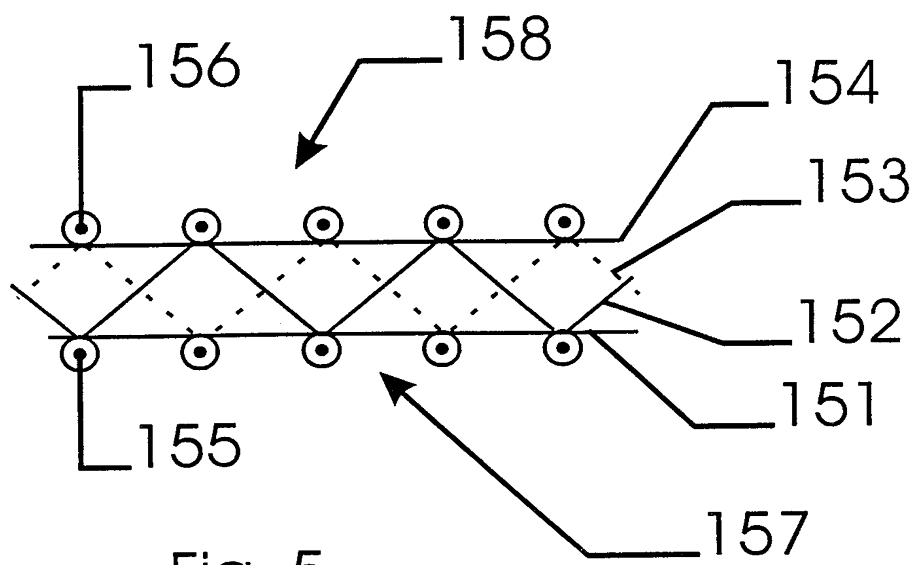


Fig. 5

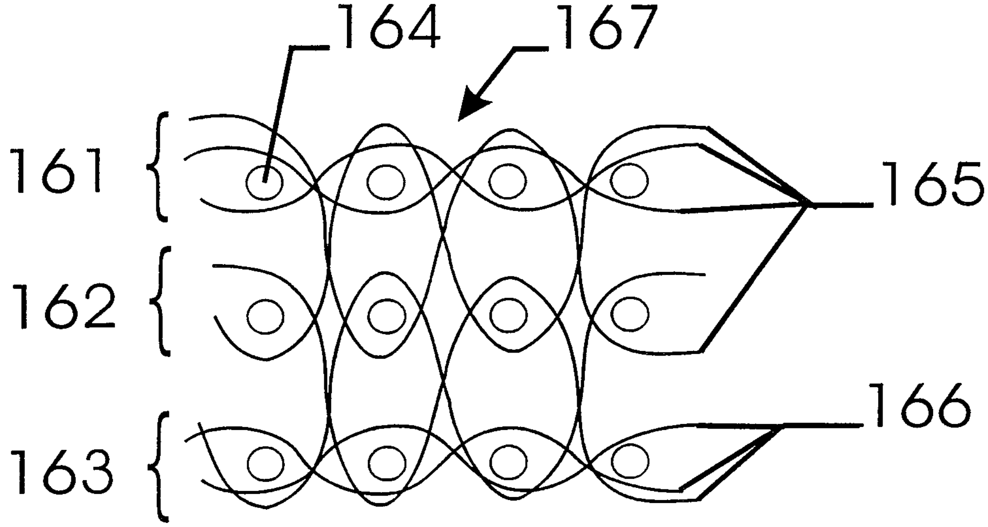


Fig. 6

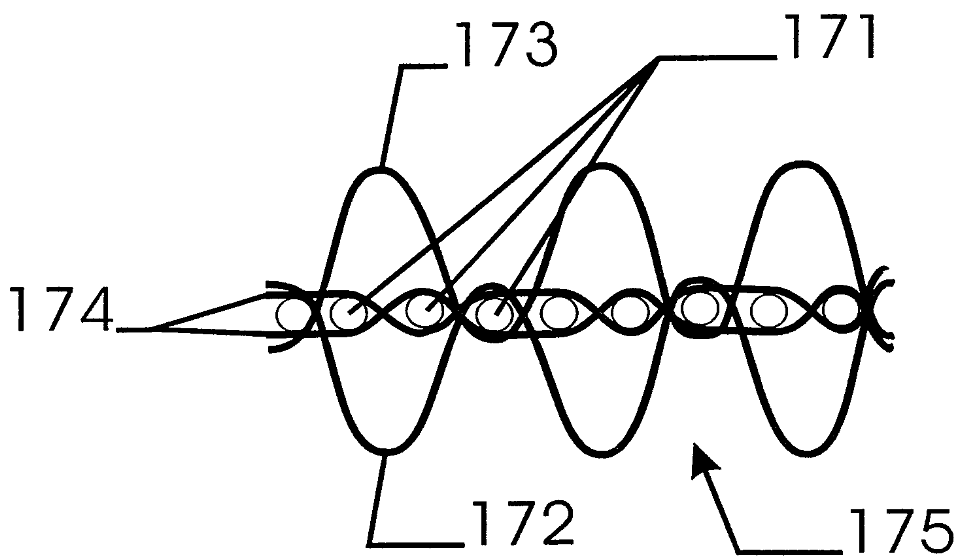


Fig. 7

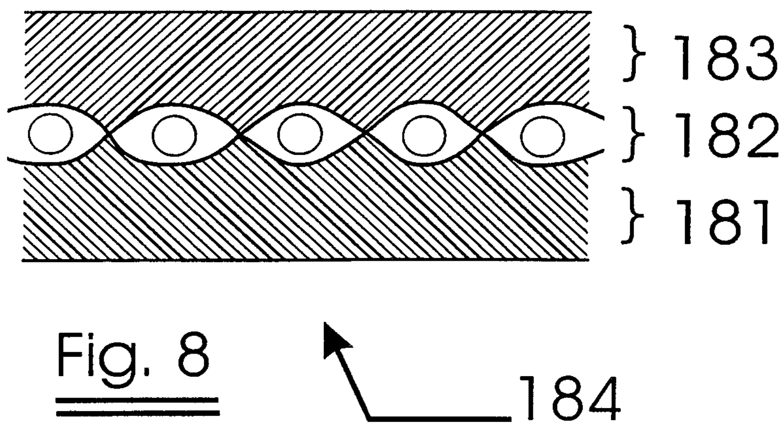


Fig. 8

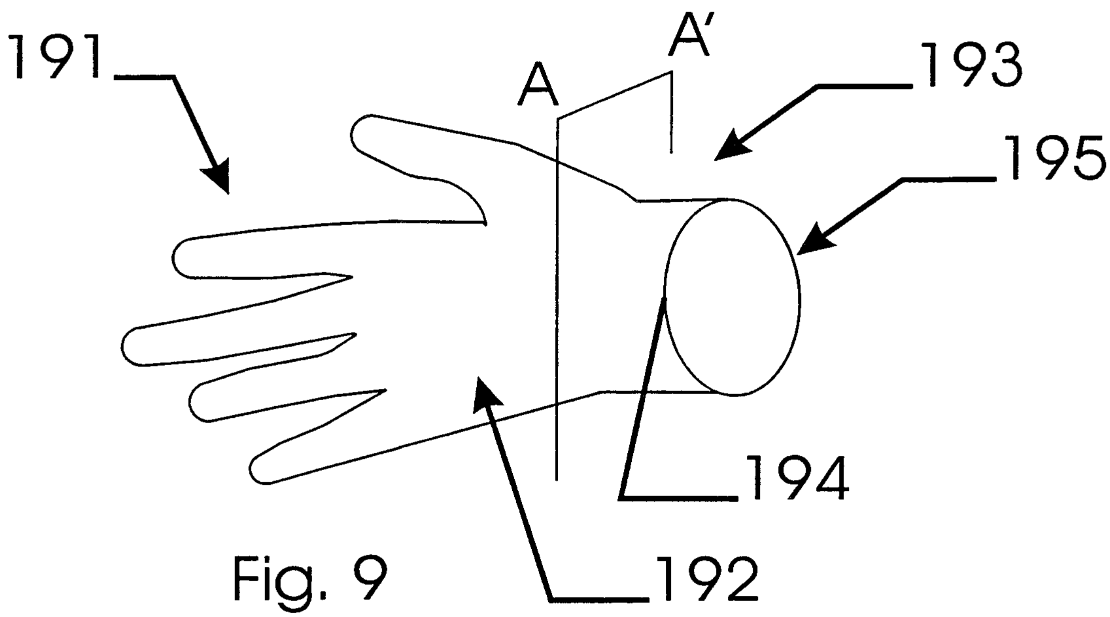


Fig. 9

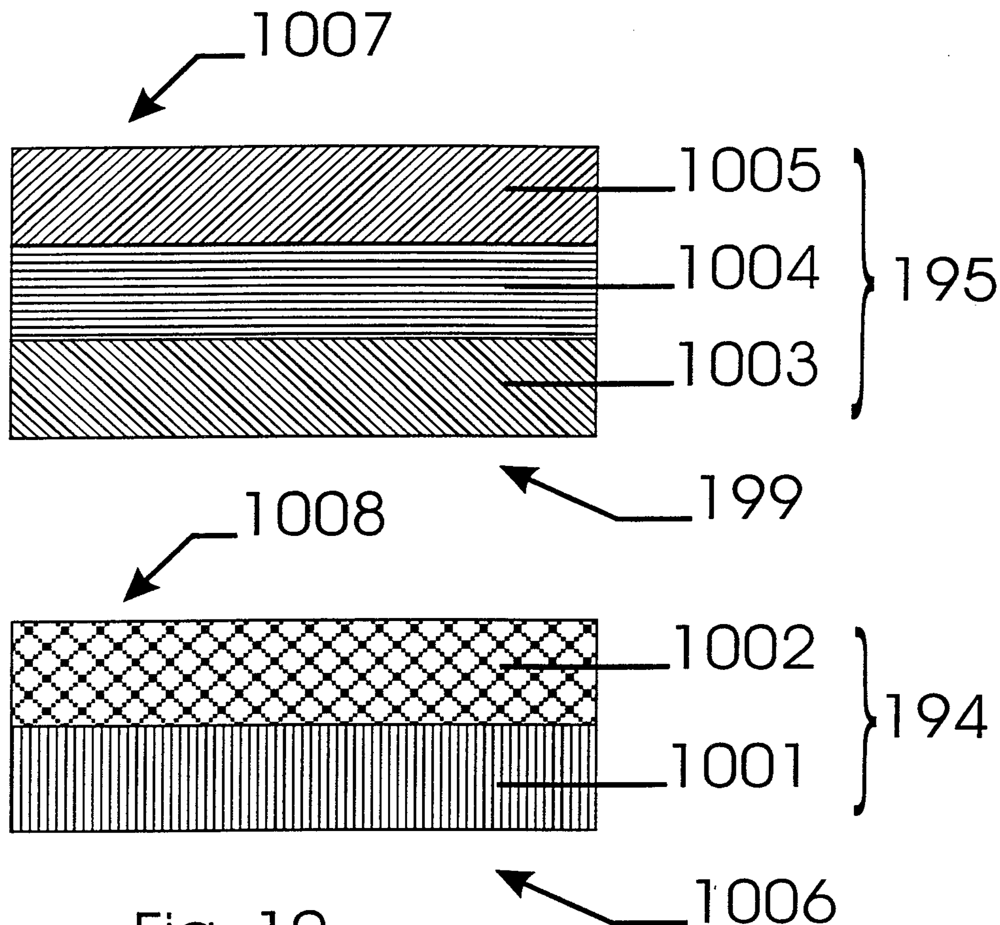


Fig. 10

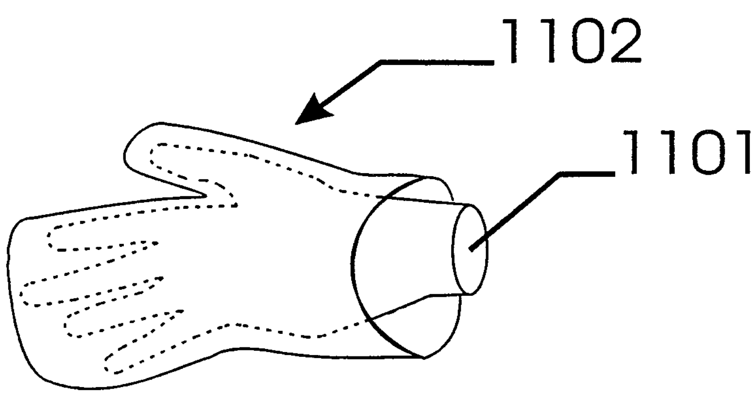


Fig. 11

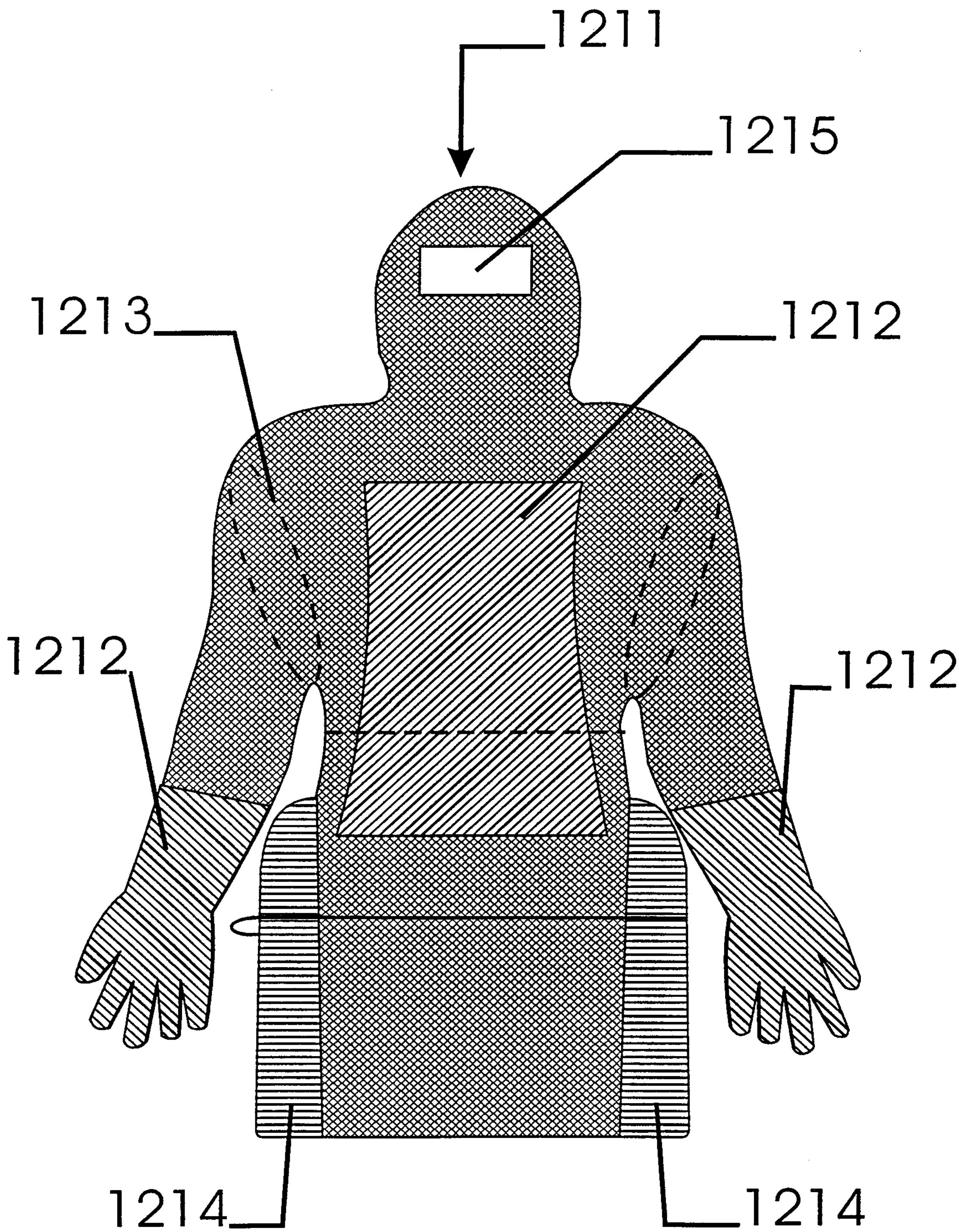


Fig. 12